Consommation et Corporations Canada
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Consumer and Corporate Affairs Canada
Patent Office

(21) (A1) 2,027,116
(22) 1990/10/09
(43) 1991/04/14
(52) 154-117
C.R. CL. 20-38.1

5,001,5/05

(51) INTL.CL.[5] B32B-3/26; B32B-3/30; B32B-33/00

(19) (CA) **APPLICATION FOR CANADIAN PATENT** (12)

(54) Bendable Composite Panel

(72) Ehrat, Rainer - Switzerland ;
Schlatter, Reinhard - Switzerland ;

(73) Alusuisse-Lonza Services Ltd. - Switzerland ;

(30) (CH) 3749/89 1989/10/13

(57) 26 Claims

Notice: The specification contained herein as filed

Abstract

The composite panel has an elasto-plastically deformable core (12) and at least one covering layer (14, 16) of a plastically or thermoplastically deformable material, arranged on one side. At least one covering layer (14, 16) of the composite panel (10) is preformed and has at least one bead (28) running in a straight line and extending over the entire width, which bead or beads allows/allow a bending of the composite panel (10) with constriction of the bead/beads.

The composite panels (10) may be used as structural elements bent on site.

The bent composite panels have a wide range of applications, in particular in architecture or in vehicle construction.

(Fig. 2)

Bendable composite panel

The invention relates to a composite panel having an elasto-plastically deformable core and at least one covering layer of a plastically or thermoplastically deformable material, arranged on one side. Furthermore, the invention relates to the use of the composite panel.

Nowadays complex bonding processes with expensive male and female moulds are used for the production of bent or domed composite panels having a foam core of plastic. In spite of the high production costs, the shaping is restricted quantitatively and qualitatively:

- Since special gauges have to be produced for each shape, the variety of shapes is very restricted.
- For the usual bending of composite panels, in the case of a small bending radius at least one wedge-shaped groove is made on the inside, which groove is closed again during bending. According to this process, the inner covering layer can no longer fulfil its vapour barrier function.

The present invention is based on the object of providing a composite panel of the type mentioned at the beginning which, in a simple way and with short time expenditure, allows flat composite panels to be subsequently deformed with virtually any desired radii without significantly reducing the composite rigidity or impairing the vapour permeability.

The object is achieved according to the invention by at least one covering layer of the composite panel being preformed and having at least one bead, running in a straight line and extending over the entire width, which bead or beads allows/allow a bending of the composite panel with constriction of the bead/beads.

By geometrically defined beads in one or both covering layers, according to the invention the cross-section of the composite panel is reduced and space is

created for bending. The geometrical cross-sectional shape of the beads is designed in such a way that no shear overstressing of the core/covering layer composite occurs during bending. The at least partial closing of the beads of a covering layer, which are formed over at least a certain region, has the effect that the composite panel can be bent or domed or curved correspondingly, the covering layer having the at least partially closed beads forming the concavely domed inner side.

The beads extend in each case over the entire width of a covering layer, where the width is not to be considered in purely geometrical terms, and beads can also extend over the entire length of a composite panel.

The beads of two opposite covering layers are preferably offset in the longitudinal direction.

Composite panels having an elasto-plastically deformable core of a thermoplastic or thermoset plastic must, in spite of their elasto-plastic deformability, also meet the requirements for mechanical rigidity after bending. Examples suitable for this purpose are foams of polyvinyl chloride, Styropor, polystyrene, polyurethane or polymethacrylate.

Depending on the intended purpose, the core may be of a closed-pore or open-pore design, and contain fire-retardant additives, for example aluminium trihydroxide, and/or mechanically reinforcing fibres, for example glass fibres or carbon fibres, in a concentration known to a person skilled in the art.

The thickness of the foam core is preferably in the range of 20 - 150 mm. Thick cores oppose the bending force with a high resistance, which could result in shear overstressing of the core/covering layer composite, for which reason the beads have to be made correspondingly deep. However, the rigidity of the composite panel must not be reduced too much. Core layers much less than 20 mm thick are scarcely able to lend the composite a usually required minimal rigidity.

The covering layer/layers preferably consists/consist of a plastically readily deformable metal and/or a thermoplastic. The thickness of the covering layer/layers is preferably in the range of 0.1 - 1.5 mm, depending on material and/or use. Metallic covering layers consist in particular of aluminium, an aluminium alloy, stainless steel or copper, thermoplastic covering layers consist of a rigid plastic, such as for example polyethylene or polypropylene.

The bonding of the covering layers to the core is performed by means of an adhesive.

With respect to the cross-section, the beads are expediently designed to be V-shaped, U-shaped, preferably in each case rounded-off, dovetail-shaped or pear-shaped. V-shaped beads can be closed over their full surface area during bending, concavely designed side surfaces form a cavity during closing due to bending, while convexly designed side surfaces of V-shaped beads prevent a complete closing of a bead.

The beads are preferably produced with a depth of 10 - 80%, preferably 20 - 50%, of the thickness of the composite panel, they are usually in the range of about 5 - 20 mm. The possible bead depth is primarily dependent on the elasto-plastic deformability of the core of plastic foam, if need be with the additives mentioned.

By variation of the spacing of the beads, their depth, their mutual angle and/or their cross-sectional shape, virtually any bending of the composite panel, in one direction or the other, can be achieved. With respect to the bending radius, the lower limit is set by the rigidity or elasto-plasticity of the core material. The elasto-plastic deformability of the core and covering layer/layers can be utilised to an extent which until now has not been considered possible.

Depending on the regular or irregular application of one or more parameters, geometrically regular or irregular bending surfaces are obtained.

The composite rigidity is not significantly impaired, the vapour impermeability of the plastically deformed covering layer is fully retained.

A composite panel provided with beads can be bent without special aids, in particular without gauges, until the beads are closed and thus the predetermined bending surface produced. In one use according to the invention, a composite panel may be used as a structural element bent on site.

In particular in the case of concave V-shaped, U-shaped or undercut beads, at least one projecting object can be clamped in the beads of the composite panel during bending:

- According to a first variant, suspension members are firmly clamped, to which the domed composite panel can be fastened, or by means of which another object can be suspended or fastened to the domed composite panel.

  The fixing of the suspension members can be improved by their shank introduced into the bead being widened rearwards and/or an adhesive being added.
- According to a second variant, equally or unequally thick calibrating plates are inserted into the beads during bending, by which a predetermined bending surface can be achieved. Equal calibrating plates produce a bending surface with constant radius, increasingly thick calibrating plates produce a less domed bending surface and thinner calibrating plates produce a more domed bending surface.

The bent or domed composite panels according to the invention have a wide range of applications, in particular in architecture or in vehicle construction. In building construction, cold façades or decorative façades of a great variety of forms can be produced, interior fittings can be distinctively styled or furniture can be produced. In the area of underground construction, a major application is in tunnel

construction, where an aesthetically appealing inner lining which meets all safety requirements can be produced. In vehicle construction, major applications are in the area of roof design, vehicle shells and containers.

The invention is explained in more detail with reference to exemplary embodiments represented in the drawing, which are also the subject of dependent claims. In the diagrammatic representation of the figures:

- Fig. 1 shows a partial section through a flat composite panel with V-shaped beads,
- Fig. 2 shows the bent composite panel according to Fig. 1,
- Fig. 3 shows a section through a U-shaped bead,
- Fig. 4 shows a section through a pear-shaped bead,
- Fig. 5 shows a section through a dovetail-shaped bead, and
- Figs. 6 to 9 show a view of composite panels with variously arranged beads.

The composite panel 10 of an essentially customary type represented in Fig. 1 has a core 12 of a thermoplastic rigid foam and approximately 0.9 mm thick covering layers 14, 16 of a ductile aluminium alloy arranged on both sides. The upper covering layer has, however, cross-sectionally V-shaped beads 28 with straight side walls at regular spacings a. The beads have a depth t, which makes up 50% of the overall thickness of the composite panel 10.

In Fig. 2, the composite panel 10 of Fig. 1 is bent to such an extent that the V-shaped beads 28 are just closed. By virtue of the V-shaped beads 28 arranged at uniform spacing a, with equal depth t and equal included angle, the lower covering layer 16, the outer surface of the bent composite panel 10, is essentially bent in the shape of a cylindrical shell.

The rounded-off, cross-sectionally U-shaped bead 28 according to Fig. 3 contains a calibrating

plate 30. During the bending of the composite panel, the intermediate space between the edges 32, 34 of the beads 28 and the calibrating plate 30 contracts. When the edges 32, 34 bear against the calibrating plate 30, bending is complete. Depending on the thickness of the calibrating plate 30, the bending radius of the composite panel is greater or smaller.

Once bending is complete, the calibrating plate 30 is drawn out from the deformed beads 28. If need be, the open bead can be filled up with a filling compound.

Inserted in the cross-sectionally pear-shaped bead 28 according to Fig. 4 there is an eyelet 36 with a shank 38. This shank 38 is in a slow-setting adhesive 40. During the bending of the composite panel 10, the intermediate space between the edges 32, 34 and the shank 38 of the eyelet contracts until the said shank is clamped. Depending on the required bearing force of the eyelet 36, the adhesive 40 may be omitted, but only if the shank 38 can be clamped with an appropriately firm seating.

The cross-sectionally dovetail-shaped bead 28 represented in Fig. 5 contains a hook 42 with rearwardly widened shank 44. During bending of the composite panel 10, the bead 28 contracts until the edges 32, 34 clamp the shank 44 of the hook. The dovetail-shaped bead 28 and the rearwardly widened shank 44 effectively prevent a tearing-out of the hook 44 even without adhesive.

The composite panel 10 represented in Fig. 6 has beads 28, represented by dashed lines, at regular spacings a. The parallel running beads 28 made to the same depth extend over the entire width of the composite panel 10. From Fig. 6 there results a composite panel 10, curved with regular bending radius, such as is represented in principle in Figs. 1 and 2.

According to Fig. 7, the beads 28 have a smaller spacing a in the central region than in the outer region. This results in a composite panel 10

which is bent more in the central region than on the outside.

If the beads 28 according to Fig. 7 are made alternatingly on the upper covering layer and the lower covering layer, an undulatingly bent composite panel 10 is produced. The beads 28 in the upper covering layer and the lower covering layer of the composite panel 10 preferably do not overlap, i.e. they should be offset in the longitudinal direction, because otherwise no usually desired closed bending outer surface is obtained.

The composite panel 10 represented in Fig. 8 shows beads 28 made in groups at a regular spacing a. The beads 28 drawn in in dashed lines are made in the upper covering layer, the beads 28 drawn in in dotted lines are made in the lower covering layer. There are no beads 28 between the groups. This arrangement of the beads 28 results in a composite panel 10 bent essentially in the shape of a Z and having a regular rounded-off radius.

An essentially U-shaped design (not shown) of the composite panel could be achieved if both groups of beads 28 were arranged in the upper covering layer or in the lower covering layer.

Fig. 9 shows a composite panel 10 having beads 28 running at a constant angle β. This arrangement produces a composite panel 10 bent in the shape of a truncated cone. The depth of the beads may be uniform or increasing in the direction of the converging beads.

The arrangement of the beads 28 which is represented by way of example in Figs. 6 - 9 has the effect that, by a combination of the parameters of spacing, angle, depth and cross-sectional shape of beads, a great variance of bending shapes can be achieved, without needing a gauge for each.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:-

1. Composite panel having an elasto-plastically deformable core (12) and at least one covering layer (14, 16) of a plastically or thermoplastically deformable material, arranged on one side, characterized in that at least one covering layer (14, 16) of the composite panel (10) is preformed and has at least one bead (28) running in a straight line and extending over the entire width, which bead or beads allows/allow a bending of the composite panel (10) with constriction of the bead/beads.

2. Composite panel according to Claim 1, characterized in that the beads (28) are designed to be V-shaped, U-shaped, preferably in each case rounded-off, dovetail-shaped or pear-shaped with respect to the cross-section.

3. Composite panel according to Claim 1 or 2, characterized in that the beads (28) are formed with a depth (t) of 10 - 80%, preferably 20 - 50%, of the thickness of the composite panel (10).

4. Composite panel according to one of Claims 1 - 3, characterized in that for the production of a composite panel (10), bent with regular radius, parallel beads (28) are formed in regular spacing (a), depth (t) and cross-sectional shape.

5. Composite panel according to one of Claims 1 - 3, characterized in that for the production of an increasingly bent composite panel (10) parallel beads (28) are formed at a decreasing spacing (a), for the production of a decreasingly bent composite panel (10) parallel beads (28) are formed at increasing spacing (a), the depth (t) and the cross-sectional shape of the beads (22) in each case remaining constant.

6. Composite panel according to one of Claims 1 - 3, characterized in that for the production of an increasingly bent composite panel (10) parallel beads (28) are formed with increasing depth (t) and uniform or decreasing spacing (a), for the production of a

decreasingly bent composite panel (10) parallel beads (28) are formed with decreasing depth (t) and uniform or increasing spacing (a), the cross-sectional shape of the beads (28) remaining constant.

7. Composite panel according to Claim 5 or 6, characterized in that for the production of an undulating shape of a composite panel (10), with covering layers (14, 16) arranged on both sides, the beads (28) are formed alternatingly offset on both covering layers (14, 16).

8. Composite panel according to one of Claims 1 - 3, characterized in that for the production of a composite panel (10), bent in the form of a truncated cone, beads (28) running at a constant, acute angle (β) are formed with the same depth (t) and cross-sectional shape.

9. Use of a composite panel (10) according to one of Claims 1 - 8 as a structural element bent on site.

10. Use of a composite panel (10) according to one of Claims 1 - 9 for the bending and clamping of at least one projecting object (30, 38, 44) in the bead/beads (28).

11. Composite panel which comprises a deformable core and at least one covering layer of a deformable material arranged on one side of the deformable core, wherein said covering layer has at least one bead running in a straight line and extending over the entire width, wherein said bead allows a bending of the composite panel with constriction of the bead.

12. Composite panel according to claim 11 wherein said covering layer has a plurality of said beads.

13. Composite panel according to claim 12 including a second covering layer on the side of the core opposed to the first covering layer.

14. Composite panel according to claim 11 wherein said at least one bead has a shape in cross-section selected from the group consisting of V-shaped, U-shaped, dovetail-shaped and pear-shaped.

15. Composite panel according to claim 14 wherein said at least one bead has edges thereof which are rounded-off.

16. Composite panel according to claim 11 wherein said at least one bead is formed with a depth (t) of 10-80% of the thickness of the composite panel.

17. Composite panel according to claim 11 wherein said composite panel is bent with a regular radius and includes a plurality of parallel beads formed with a regular spacing (a), depth (t) and cross-sectional shape on said covering layer.

18. Composite panel according to claim 11 wherein said composite panel is bent and includes a plurality of parallel beads formed with a decreasing spacing (a), and with a constant depth (t) and cross-sectional shape.

19. Composite panel according to claim 11 wherein said composite panel is bent and includes a plurality of parallel beads formed with an increasing spacing (a), and with a constant depth (t) and cross-sectional shape.

20. Composite panel according to claim 11 wherein said composite panel is bent and includes a plurality of parallel beads formed with increasing depth (t), spacing (a) selected from the group consisting of uniform and decreasing spacing (a), and a constant cross-sectional shape.

21. Composite panel according to claim 11 wherein said composite panel is bent and includes a plurality of parallel beads formed with decreasing depth (t), spacing (a) selected from the group consisting of uniform and increasing, and a constant cross-sectional shape.

22. Composite panel according to claim 13 wherein said composite panel has an undulating shape and wherein the beads (28) are formed alternatingly offset on both covering layers.

23. Composite panel according to claim 12 wherein said beads run at a constant, acute angle (β) and are formed with the same depth (t) and cross-sectional shape for the formation of a composite panel bent in the form of a truncated cone.

24. Composite panel according to claim 12 in the form of a bent structural element.

25. Composite panel according to claim 11 including at least one object projecting from said at least one bead.

26. Composite panel according to claim 25 wherein said panel is bent and wherein said object is clamped in said bead.

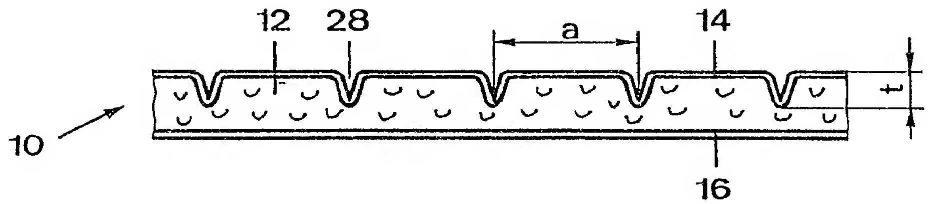

Fig. 1

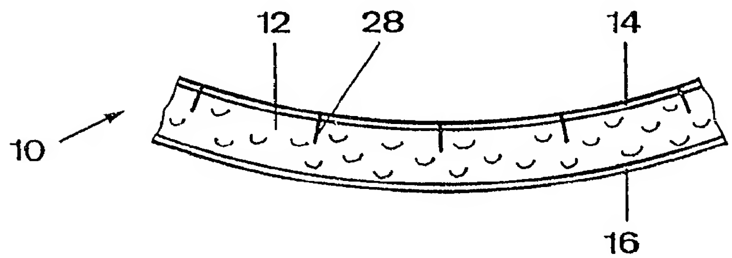

Fig. 2

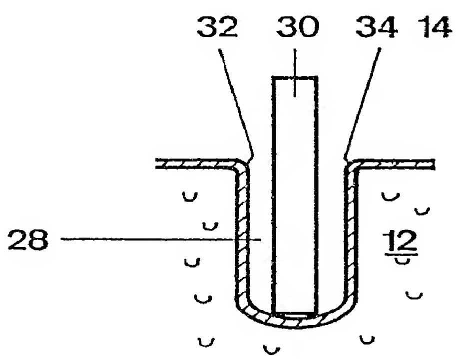

Fig. 3

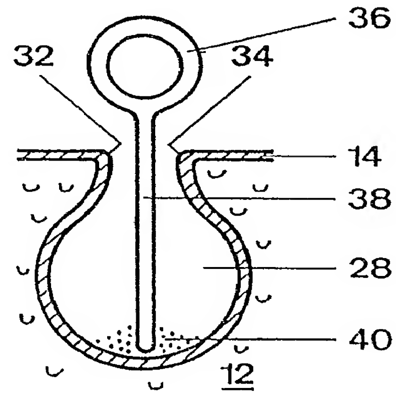

Fig. 4

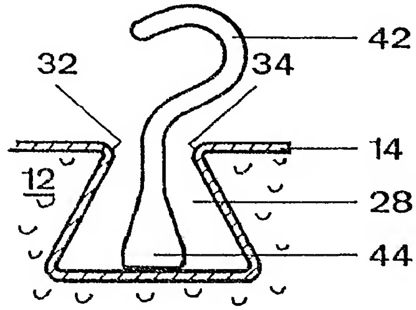

Fig. 5

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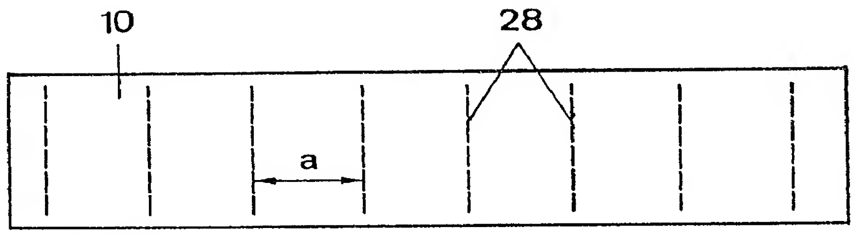

Fig. 6

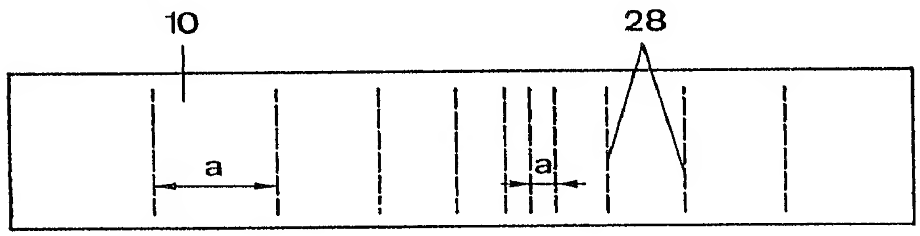

Fig. 7

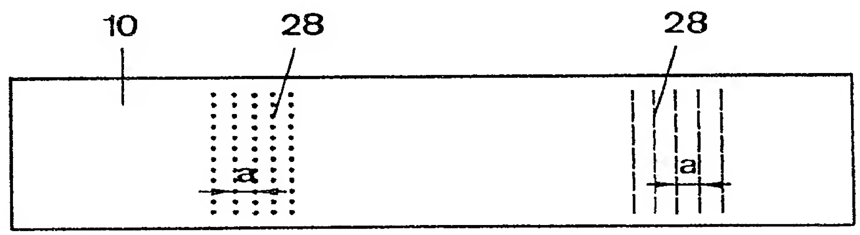

Fig. 8

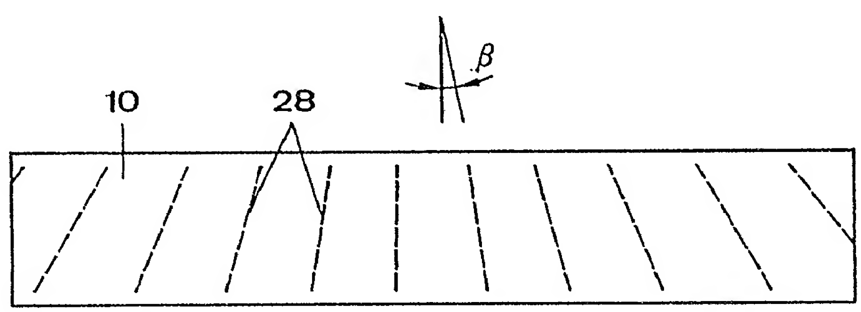

Fig. 9

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